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BULLETIN

OF THE

TORREY BOTANICAL CLUB

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TORREY BOTANICAL CLUB

MARCH, 1924

New Polygalas from Colombia

S. F. Blake

Polygala diversa sp. nov.

Frutescent, sometimes flowering the first year, densely pubescent; leaves oval to elliptic, 1.5–4 cm. long, 7–14 mm. wide; racemes short, 12–15 mm. thick, short-peduncled; bracts deciduous; pedicels 1.5–2 mm. long; sepals ciliolate with glandular and eglandular hairs; wings suborbicular-obovate, 6.5–7 mm. long, 4.5–5.8 mm. wide, inequilateral, densely spreading-pubescent and ciliate; capsule quadrate-oval, 5 mm. long, ciliolate; seed 4 mm. long, silky-pilose.

Frutescent, up to 90 cm. high, much branched, but flowering also as a simple-stemmed annual only 18 cm. high; stem 5 mm. thick or less, terete, densely incurved-pubescent or ascending-pubescent, often with spreading hairs intermixed; leaves alternate; petioles 1–2 mm. long, pubescent like the stem; blades oval to elliptic or ovate-elliptic, 1.5–4 cm. long, 7–14 mm. wide, acute or acuminate to rounded, sometimes mucronulate, at base rounded to cuneate, papery, above evenly spreading- or ascending-puberulous, glabrescent except toward margin, beneath about equally green, spreading-pubescent, more densely so along the veins, these 3–5 pairs, prominulous beneath, the secondaries obscure; peduncles terminal and supra-axillary, 5 mm. long or less; racemes 12–25 mm. long, 12–15 mm. thick, obtuse or acute, slightly comose, pubescent like the stem, the axis becoming 4 cm. long or less; bracts subulate, 1.5 mm. long, hispid-pilose, deciduous; pedicels puberulous, 1.5–2 mm. long; flowers "pink or violet-pink"; upper sepal oblong-ovate, 3.5–3.8 mm. long, obtuse, densely ciliolate with eglandular hairs for its basal third, above bearing about 8 pairs of stipitate glands and a few eglandular hairs, on back spreading-puberulous; lower sepals united nearly to apex, obtuse, 2.8 mm. long, spreading-puberulous on back, bearing about 10 pairs of stipitate glands from base to apex, the eglandular hairs few; wings suborbicular-obovate, 6.5–7 mm. long, 4.5–5.8 mm. wide, strongly inequilateral, emarginate, at base unequal, cuneate on one side,

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obliquely rounded 1 mm. above base on other side, rather densely and evenly spreading-pubescent outside and ciliate, about 5-veined, the veins forked above and anastomosing toward the margin; upper petals 4.8 mm. long, pilose within to middle, the limb oblong-obovate, rounded, glabrous, about 7-nerved; keel 5 mm. long, ciliate at extreme base, not ciliate on the upper margin of the saccate portion, spreading-pubescent on the outer anterior face of the saccate portion; capsule quadrate-oval, 5 mm. long, 4.2–4.8 mm. wide, ciliolate, narrowly margined, emarginate, at base subcordate; seed 4 mm. long (including aril), oblong-oval, terete, densely appressed-silky-pilose; aril 1.3 mm. high, 1.8 mm. long, casque-shaped, white, subcorneous, sparsely pilose, 3-lobed from near the middle, the lobes equal, the dorsal the broadest.

COLOMBIA: On sandstone cliff at Honda, Dept. Tolima, 250–350 m., 3–4 Jan. 1918, *F. W. Pennell 3602* (TYPE in herbarium of the N. Y. Botanical Garden; duplicate in U. S. National Herbarium). Open clayey loam, Melgar, Dept. Cundinamarca, 500–600 m., Dec. 1917, *Pennell 2902*. Open woodland, west of San Lorenzo, Dept. Tolima, 500–700 m., Dec. 1917, *Pennell 3549*. Open rocky slope, Honda, Dept. Tolima, 300–400 m., Jan. 1918, *Pennell 3582*.

Polygala diversa belongs in the subgenus *Hebeclada*, and may be distinguished readily by its densely pubescent wings. At maturity it is distinctly frutescent, but it also flowers as a seedling, as shown by *Pennell 3549*, which in all other characters is identical with the type of the species.

P. Smithii sp. nov.

Suffrutescent, densely incurved-puberulous; leaves ovate, 5.5–8 cm. long; racemes 1.2–5 cm. long, 1–1.4 cm. thick; bracts deciduous; pedicels 1–2 mm. long; sepals densely ciliate with eglandular hairs; wings obliquely oval-obovate, 5–6 mm. long, 3.8–4.5 mm. wide, inequilateral, ciliolate; capsule quadrate-oval, 4–4.8 mm. long, shorter than the wings; seed 4.2 mm. long, subsericeous-pilose.

Suffrutescent, erect, about 1 meter high, simple or sparsely branched, the base not seen; stem subterete, 2–3 mm. thick, greenish, densely incurved-puberulous, a few longer straighter hairs sometimes present; leaves alternate; petioles pubescent like the stem, 2–4 mm. long; blades ovate, 5.5–8 cm. long, 2–4.2 cm. wide, acuminate (sometimes abruptly so), at base cuneate or rounded-cuneate, membranaceous, above deep green, evenly spreading-puberulous on surface (the hairs along the veins shorter and incurved), beneath sparsely spreading-puberulous on surface,

along the veins incurved-puberulous and sparsely spreading-pubescent, the veins 7–8 pairs, prominulous beneath, the secondaries obscure; peduncles terminal and supra-axillary, 4 mm. long or less; racemes loose or rather dense, 1.2–5 cm. long, obtuse to acute, slightly comose, 1–1.4 cm. thick, the axis becoming 10 cm. long or less, pubescent like the stem; bracts lance-subulate, 1.8 mm. long, attenuate, hispid-pilose, deciduous; pedicels glabrous, curved, 1–2 mm. long; flowers greenish; upper sepal oblong-ovate, 3 mm. long, obtuse, densely ciliate with eglandular hairs; lower sepals similar, 2.2 mm. long, united for four-fifths their length, obtuse; wings obliquely oval-obovate, 5–6 mm. long, 3.8–4.5 mm. wide, strongly emarginate, inequilateral, cuneate at base on one side, contracted 1.2 mm. above base on other, ciliolate except on narrowed basal portion, 4-nerved, the nerves branched and anastomosing toward margin; upper petals 3.5 mm. long, pilose within except on the expanded portion of limb, this oblong-ovate, rounded, erose, many-nerved; keel 4.2 mm. long, pilose-ciliate on the posterior upper margin of the saccate portion; capsule quadrate-oval, 4–4.8 mm. long, 4–4.7 mm. wide, distinctly shorter than the wings, margined, emarginate at apex, subcordate at base, not stipitate, glabrous; seed oval, terete, 4.2 mm. long (including aril), 1.8 mm. wide, rounded at apex, densely subsericeous-pilose with subappressed hairs; aril 1.8 mm. high and wide, sparsely pilose, rounded-quadrate, compressed, with much excavated sides, yellowish-white, not corneous, with three subequal rather short rounded lobes.

COLOMBIA: In dry forest near Agura Dulce, vicinity of Santa Marta, 8 June 1898–1899, *Herbert H. Smith 1309* (TYPE in herbarium of the N. Y. Botanical Garden; duplicate of this number in U. S. National Herbarium, no. 533,456, labeled October 1898–1901). Lower hills on the trail from Río Frío to San Andrés de la Sierra, State of Magdalena, 400 m., July 1906, *Pittier 1714*.

This species is a member of the section *Apopetala* of the subgenus *Hebeclada*, and is nearest *P. Vauthieri* Chod., which is described as having lanceolate or lance-oblong leaves and larger wings (up to 8 mm. long), these as wide as long. The type collection was distributed as *P. violacea* Vahl, but the original *P. violacea* Aubl., a still doubtful species, is described as having a crested keel.

Polygala Fendleri heterothrix var. nov.

Leaves sometimes nearly all in (2–4) whorls; hairs of seed straight; otherwise as in *P. Fendleri*.

COLOMBIA: Dry grassy bank, Guayabotal, southeast of Quetame, Dept. Cundinamarca, 1300–1400 m., 5 Sept. 1917, *F. W. Pennell 1746* (TYPE in U. S. National Herbarium, no. 1,041,907; duplicate in herbarium of N. Y. Botanical Garden).

The group of the subgenus *Orthopolygala* known as the Series *Glochidiatae* is characterized principally by the uncinate hairs clothing the seed. In the variety above described, however, the hairs of the seed are straight, although the most careful comparison has failed to disclose any other constant difference from *P. Fendleri* Chod. in habit or structure. The occurrence of a very few hook-tipped hairs on some of the seeds, moreover, shows conclusively that the plant in question is merely an anomalous form of *P. Fendleri* and not a mimetic species of the group *Tenues*, to which I was at first inclined to refer it.

Polygala Fendleri Chod. was based on *Fendler 238*, from Colonia Tovar, Venezuela. The following specimens agree with the type collection in every respect except in having the crest on each side composed of a lamella and a single linear lobe, while there are a lamella and two linear lobes in *P. Fendleri*. The seeds in the specimens of the type collection examined, kindly lent from the Gray Herbarium and the herbarium of the New York Botanical Garden, are obtusish at each end, not attenuate as described, and rather densely pubescent with somewhat spreading hairs which are as distinctly uncinate as they are in any of this group.

COLOMBIA: Open rocky ridges and grass lands above Jivacasaca, vicinity of Santa Marta, 915–1065 m., 27 Sept. 1898–1899, *Herbert H. Smith 1306* (U. S., N. Y. Bot. Gard.; distr. as *P. paniculata*). In open loam, El Convenio, west of San Lorenzo, Dept. Tolima, 1000–1200 m., Dec. 1917, *F. W. Pennell 3494* (N. Y. Bot. Gard.).

Polygala Pennellii sp. nov.

Glabrous annual; lower leaves whorled, the others alternate, linear; racemes subcapitate or short-cylindric, acute; flowers white, pedicellate; bracts caducous; wings oval or obovate-oval, 1.8–2 mm. long, 1.2 mm. wide, rounded, short-clawed; crest of 2 pairs of 2-lobed or bifid segments; capsule oval, 1.7 mm. long, very short-stipitate, equaling the wings or one-fourth shorter; seed densely uncinate-pilose; aril obsolete.

Slender single-stemmed annual, freely branched, 12–33 cm. high; stem subterete, glabrous; lower leaves in about 5 whorls

of about 4, or sometimes opposite or ternate on the branches, the others alternate, linear, 4–9 mm. long, 0.3–0.6 mm. wide, cuspidate-acuminate, subsessile, revolute-margined, glabrous; peduncles terminal and axillary, 3–19 mm. long; racemes subcapitate or short-cylindric, rather dense, acute, not comose, 3–12 mm. long, 2.5–4.5 mm. thick, the axis becoming 14 cm. long or less; bracts ovate, acuminate, glabrous, 1-nerved, caducous, 0.7 mm. long; pedicels 0.5–0.8 mm. long; flowers white; upper sepal ovate-oval, 1 mm. long, obtuse, 1-nerved; lower sepals similar, oval, 0.8 mm. long; wings oval or obovate-oval, 1.8–2 mm. long, 1.2 mm. wide, rounded, at base rather abruptly short-clawed (claw 0.4 mm. long), 3-nerved, the lateral nerves extending to middle; upper petals 1.5 mm. long, the free portion oblong-ovate, obtuse, about 3-veined; keel 1.8 mm. long, the crest on each side of a 2-lobed lamella and a single lobe 2-fid to middle; capsule oval, 1.7 mm. long, 1.2 mm. wide, equaling the wings in fruit or about one-fourth shorter, emarginulate, at base cuneate-rounded and usually unequal, very short-stipitate; seed oval, 0.7 mm. long, obtuse at each end, densely uncinate-pilose, the hairs about two-thirds as long as the diameter of the seed; aril obsolete.

COLOMBIA: On open foothill in the Cordillera Oriental, east of Neiva, Dept. Huila, 1000–1700 m., 1–8 August 1917, *H. H. Rusby & F. W. Pennell 534* (TYPE in herbarium of the N. Y. Botanical Garden; photograph in U. S. National Herbarium). Fusagasugá, 3 Jan. 1853, *I. F. Holton* (N. Y. Bot. Gard.). Open clayey loam, Melgar, Dept. Cundinamarca, 500–600 m., Dec. 1917, *Pennell 2890* (N. Y. Bot. Gard.).

This species is a close relative of *P. Fendleri* Chod. It seems distinct, however, in its smaller distinctly short-clawed wings and its oval capsule which is usually nearly or quite as long as the wings, while in the other species, *P. Fendleri*, the distinctly obovate capsule is much shorter than the wings.

Polygala subsecunda sp. nov.

Incurved-puberulous annual; leaves alternate, linear; racemes cylindric, acutish; flowers rosy, pedicellate; bracts caducous; wings elliptic to obovate-elliptic, 2.3–3 mm. long, 1.1 mm. wide, rounded; capsule elliptic, 3.5 mm. long, about one-fourth longer than the wings; seed obconic, silky-comose, 2.7 mm. long; aril 0.4 mm. long.

Slender one-stemmed erect annual, simple or sparsely branched, 27–50 cm. high; stem subterete, sparsely and finely incurved-puberulous; leaves (except sometimes for a basal whorl of 4) alternate, linear or linear-acicular, 7–19 mm. long, 0.3–1 mm.

wide, cuspidate-acuminate, subsessile, obscurely papillose, slightly revolute-margined, 1-nerved, chiefly erect or ascending; peduncles terminal, rarely axillary, 3–10 mm. long; racemes slender-cylindric, acutish, loose, slightly comose at apex, secund or subsecund especially in fruit, 5–9 cm. long, 3–7 mm. thick, the axis becoming 19 cm. long or less; bracts obovate or oblong-obovate, 1.8 mm. long, abruptly attenuate above by the excurrent costa (this 0.4 mm. long), erose above, glabrous, caducous; pedicels glabrous, 0.8–1 mm. long; flowers "light rosy"; upper sepal ovate-oval, rounded, 1.2 mm. long, 1-nerved, glabrous, slightly glandular-thickened along the costa; lower sepals similar but narrower, oblong, 1.2 mm. long; wings elliptic, oval-elliptic, or slightly obovate-elliptic, 2.3–3 mm. long, 1.1 mm. wide, rounded, cuneate at base, glabrous, 3-nerved, the nerves simple, the lateral ones usually reaching nearly to apex; upper petals 2.5–3 mm. long, equaling wings, the free portion ovate, 4-veined, narrowed to an obtuse or truncate-rounded apex; keel 2.8–3.2 mm. long, slightly exceeding the wings and upper petals, the crest on each side of an ovate sometimes lobed lamella and two 2- to 4-parted lobes; upper stigmatic lobe slightly stipitate; capsules elliptic, 3.5 mm. long, 1.2 mm. wide, emarginulate, rounded at base, not gland-bearing, chiefly spreading in fruit, about one-fourth longer than the wings; seed obconic, silky-comose, 2.7 mm. long (including coma), short-rostrate at base; aril 0.4 mm. long, 2-lobed, appressed.

COLOMBIA: Open grass lands, near Escoleva de los Indios, vicinity of Santa Marta, 240 m., August 1898–1899, *Herbert H. Smith 575* (TYPE in U. S. National Herbarium, no. 533,071; duplicate in herbarium of the N. Y. Botanical Garden).

A member of the Series *Trichospermae*, as nearly related to *P. variabilis* H. B. K. as to any other described species, but readily distinguished by its long, slender racemes and its eglandular capsule distinctly longer than the wings. The type collection was distributed as *P. paniculata* L., a species of a different series. The original label of the sheet in the New York Botanical Garden herbarium states that the species is fairly common in open grass lands between 150 and 750 meters elevation, flowering from July to October.

Polygala apodanthera sp. nov.

Incurved-puberulous annual; leaves alternate, linear; racemes cylindric, acuminate; flowers pale pink, pedicellate; bracts caducous; wings elliptic, obtuse, 3–3.2 mm. long, 1.2 mm. wide; crest plurifid; capsule elliptic, 3.3–3.8 mm. long, not stipitate, distinctly exceeding the wings; seed short-rostrate, 2 mm. long, spreading-pilosulous; aril 2-lobed, 0.5–0.7 mm. long.

Slender erect annual, 23–38 cm. high, with few erect branches; stem below the inflorescence finely puberulous with incurved glanduliform hairs; leaves alternate except for one or two basal pairs, numerous, rather crowded, erect, linear, 1–2 cm. long, 0.5–1 mm. wide, acute, cuspidulate, very shortly petioled, 1-nerved; peduncles 3 to 8 mm. long, terminating stem and branches; racemes cylindric, dense above, loose below, acuminate to an obtusish somewhat comose apex, occasionally secund, 2–9.5 cm. long, 5–7 mm. thick, the axis becoming 15.5 cm. long or less, rather densely puberulous with longer hairs than those of the stem; pedicels glabrous, 0.6–1 mm. long, spreading or recurved at maturity; bracts oval, abruptly cuspidate-acuminate, erose above, caducous, 1.8 mm. long; flowers pale pink, the upper petals and keel apparently more purplish; upper sepal oval-ovate, obtuse, 1-nerved, 1.2 mm. long; lower sepals elliptic-oblong, obtuse, 1-nerved, 1.2 mm. long; wings elliptic, 3–3.2 mm. long, 1.2 mm. wide, equaling the keel, obtuse, cuneate but not clawed at base, 3-nerved, the nerves simple; keel 3.1 mm. long, the crest on each side of a 3-fid or 3-parted lamella and a 2-parted lobe; upper petals shorter than keel, the free portion obliquely ovate, obtuse, 3- or 4-nerved; anthers sessile or subsessile; capsule elliptic, 3.3–3.8 mm. long, 1.5 mm. wide, emarginulate, not stipitate, about one-fourth longer than the wings; seed subcylindric, short-rostrate, 2 mm. long, rather densely spreading-pilosulous; aril attached to the beak, 2-lobed, 0.5–0.7 mm. long, the lobes oblong, obtuse or sometimes acutish.

COLOMBIA: Rocky bank in prairie, Mariquita, Dept. Tolima, 250–300 m., 7 Jan. 1918, *F. W. Pennell 3638* (TYPE in U. S. National Herbarium, no. 1,044,846; duplicate in herbarium of the New York Botanical Garden).

A species of the *Tenues* group, nearest the Venezuelan *Polygala Funkii* Chod., in which, according to description, the stem and raceme axis are glabrous, the wings and sepals acute, the crest on each side composed of a lamella and a slender lobe (both entire), and the free portion of the filaments nearly as long as the anthers.

Studies in the genus Lupinus—X. The Micranthi concluded

CHARLES PIPER SMITH

(WITH TEXT FIGURES 92–94)

My treatment of this group was introduced in the seventh paper of this series (Bull. Torr. Club **49**: 204. 1922). The list of published names and combinations there given shows that at least nineteen proposed species, plus some seven "ined." proposals, have called for consideration in the preparation of this review. Careful study of all these propositions, with the exception of one Mexican form, has now been completed, the result being that just seven real species seem to stand the test given them. Six of these are indicated and contrasted in the following key.

KEY TO THE SPECIES OF THE MICRANTHI

Densely velvety pubescent with short, spreading hairs; flowers 10 mm. long; pods 8–10 mm. wide; seeds 5–6 mm. long. 2. *L. niveus.*

Loosely villous and (or) minutely appressed or spreading pubescent, but not velvety.

Pedicels 3–8 mm. long; flowers 8–16 mm. long, banner suborbicular or wider than long; verticils four to several. 1. *L. nanus.*

Pedicels 1–3 mm. long; flowers 5–12 mm. long; verticils one to five.

Stems quite fistulous, flattening in the press; flowers 8–10 mm. long, banner suborbicular or broader than long. 3. *L. chihuahuensis.*

Stems more solid, not flattening in the press.

Keel non-ciliate.

Banner suborbicular or obcordate; flowers about 8 mm. long; pods 6–9 mm. wide; seeds 4–5 mm. long by 3–3.5 mm. wide. 5. *L. pachylobus.*

Banner obovate, rhombic, or elliptic, longer than wide; flowers 5–7 mm. long; seeds 2–3 mm. long by about 2 mm. wide. 6. *L. bicolor.*

Keel ciliate on the free edges above, between middle and apex.

Keel slender, with long, narrow acumen, nearly straight to much arcuate; banner orbicular-obcordate, obovate, rhom-

bic, or oblong-spatulate, more often longer than wide; flowers 5–12 mm. long. 6. *L. bicolor.*

Keel short and broad, the blunt acumen little or not at all upturned; banner cuneate or spatulate; flowers 5–8 mm. long. 7. *L. micranthus.*

1. LUPINUS NANUS Dougl., Benth. Trans. Hort. Soc. II, **1**: 409. 1835.

This species was treated in the eighth paper of this series (Bull. Torr. Club **50**: 159. 1923).

2. LUPINUS NIVEUS Wats., Proc. Am. Acad. **11**: 126. 1876.

Treated in the seventh paper (Bull. Torr. Club **49**: 205. 1922).

3. LUPINUS CHIHUAHUENSIS Wats., Proc. Am. Acad. **21**: 423. 1886. [Fig. 92.]

Annual, erect, 25–45 cm. tall, simple or branched, fistulous, inconspicuously short-appressed hairy, with fewer, spreading, stiff hairs; leaves several, not crowded at the base, somewhat hairy on both sides, especially on the margins; petioles 6–8 mm. long, villous; stipules conspicuous, linear, with long filiform free portion; leaflets five to seven, oblanceolate, obtuse or broadly acute, 15–40 mm. long, 4–12 mm. wide; peduncles 5–15 cm. long, villous, equaling or surpassing the leaves; racemes 5–10 cm. long; flowers 8–10 mm. long, subverticillate; bracts linear, deciduous, about equalling the calyx; pedicels 2–3 mm. long, spreading-pubescent; calyx appressed- or subappressed-pubescent, minutely bracteolate, upper lip two-toothed or bifid, about 4 mm. long, lower lip entire and acute, 6–7 mm. long; petals broad, mostly blue, banner 8–10 mm. long by 8–11 mm. wide, glabrous, wings elliptic or oblong, 8–10 mm. long by 5–7 mm. wide, keel covered by the wings, ciliate on the upper edges along the acute upturned acumen, 8–10 mm. long: pods 20–25 mm. long by 4–5 mm. wide, ovules five to seven; seeds about 2.5 mm. long by 2 mm. wide, pale yellowish and finely mottled; roots stout, 10–15 cm. long, much shorter than the stems.

The above diagnosis is practically that of Watson, as supplemented for me by Mr. I. M. Johnston, from the type specimen at the Gray Herbarium. With this type sheet are dissections of a flower, from which, through the kindness of Dr. Robinson, I was permitted to get drawings for the accompanying figure. For purposes of record only, and the convenience of others, I am citing here the two Gray Herbarium specimens. Although I

have not seen these, Mr. Johnston's critical notes have made it possible for me to recognize the species and name the Arizonan collection here recorded.

CHIHUAHUA: Cumbre, on the summit of the mountains above Batopilas, 8850 feet, 1885, *E. Palmer 318* (G); summits of the Sierra Madre, Oct., 1887, *C. G. Pringle 1483* (G).

ARIZONA: Cochise County: Chiricahua Mountains, May, 1894, *W. W. Price* (DS, CPS).

This appears to be a species with fair characters, although closely allied to *L. nanus*, which it resembles not a little. The fistulous character of the stems and branches seems to be one of its strongest peculiarities.

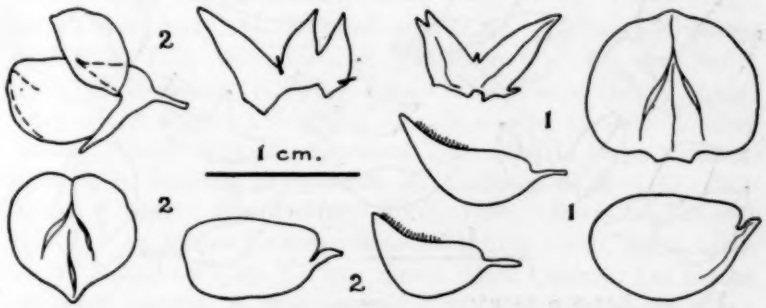

Fig. 92. LUPINUS CHIHUAHUENSIS Wats. 1. *E. Palmer 918*, Chihuahua (G). 2. *W. W. Price*, Arizona (CPS).

4. LUPINUS ASCHENBORNII S. Schauer, Linnaea **20**: 739. 1847.

In my seventh paper I listed this species as a member of the *Micranthi*. This was done because I have, for some four years, been interpreting a certain Chihuahuan plant as Schauer's species. His description is unusual in its comprehensiveness, and applies quite well to the specimens concerned; but no hint is given as to the ciliation of the keel. Recently, however, I have been favored with flowers for dissection from specimens from Southern Mexico and Costa Rica, all labelled *L. Aschenbornii*. Since three possible species seem to be included in this small assortment of material, I now feel it necessary to withhold my treatment of both Schauer's species and the Chihuahuan plant until after I have had opportunity to study Aschenborn's

own collection, especially since the actual type locality of same is unknown.

5. LUPINUS PACHYLOBUS Greene, Pittonia 1: 65. 1887. [Fig. 93.]

Lupinus micranthus pachylobus (Greene) Jepson, Fl. West. Mid. Cal. ed. 1: 318. 1901.

Annual, stoutish, 10–30 cm. tall, usually branched at the base, villous with spreading hairs 1–2 mm. long; leaves several, not crowded; petioles slender, 6–8 cm. long; stipules subulate, 7–10 mm. long; leaflets six to eight, linear-oblanceolate to elliptic-oblanceolate, 15–25 mm. long by 2–4 mm. wide, hairy on both sides; peduncles 6–8 cm. long; racemes loose, of two to four

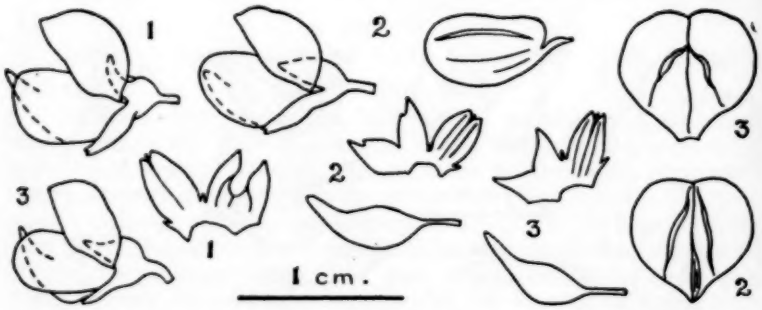

Fig. 93. LUPINUS PACHYLOBUS Greene. 1. *E. B. Copeland*, Baker distribution 3043, Butte County (US). 2. *A. A. Heller 10,682*, Butte County (CPS). 3. *C. P. Smith 3232*, Santa Clara County (CPS).

whorls; flowers few, 6–8 mm. long, sometimes almost scattered; bracts shorter than the calyx, early deciduous; pedicels short, 1–2 mm. long; calyx much shorter than the petals, its upper lip bifid, 2–4 mm. long, lower lip usually three-toothed, broad, 3–5 mm. long; petals blue, except the white center of the banner, which is suborbicular, 6–8 mm. wide, usually as wide as long, wings 6–8 mm. long and about 4 mm. wide; keel non-ciliate, somewhat arcuate, with slender acumen; pods especially large, 25–30 mm. long, 6–9 mm. wide, usually thick and succulent when green, ovules four to six; seeds 4–5 mm. long, 3–3.5 mm. wide, brown, more or less marked with darker brown lateral and marginal lines; roots slender, much shorter than the stems; cotyledons of the seedlings about 15 by 10 mm., with petioles about 5 mm. long (*Heller 11,150*).

While I feel justified in maintaining this as a distinct species, I must admit that certain forms of *L. bicolor*, in flower, approach

close to it, and have been, and probably still will be, confused with same. Those, however, have the keel ciliate, and the pods and seeds as in typical *L. bicolor*. The species is evidently very local in the southern part of its range, as I have made three trips into the type region without finding a trace of it, and I also failed to find it where found by Bradshaw. It is scarce and very restricted at its Los Gatos station.

CALIFORNIA. Butte County: Chico, April, 1903, *E. B. Copeland*, Baker distribution 3043 (B, BP, CA, UC, US); Oroville, March, 1913, *A. A. Heller 10,682* (DS, UCX, US, CPS); same, Dec., 1913, *A. A. Heller 11,150* (CA, DS, UCX). Calaveras County: Mokelumne Hill, *F. E. Blaisdell* (CA, CPS). Contra Costa County: Mount Diablo, May, 1862, *W. H. Brewer 1074* (UC); same, March, 1892, *G. W. Dunn* (CA); same, May, 1915, *A. Eastwood 4498* (CA). Eldorado County: near Pilot Hill, May, 1909, *K. Brandegee* (B, UC), and April, 1915, *K. Brandegee* (UC). Glenn County: near Orland, May, 1915, *A. A. Heller 11887* (UCX). Mariposa County: Cathey Valley, April, 1915, *A. Eastwood 4350* (CA). Napa County: Mount St. Helena, May, 1918, *A. Eastwood 6844* (CA). San Diego County: Sweetwater, April, 1908, *Christino Simpson* (UC). San Mateo County: Woodside, hills north, April, 1922, *R. V. Bradshaw 2599* (CPS). Santa Clara County: Los Gatos, March, 1907, *R. L. Pendleton 534* (UC); same, March, 1912, *A. A. Heller 10,379* (CA, DS, US); same, March, 1921, *C. P. Smith 3232* (CPS). San Antonia Creek hills, March, 1898, W. R. Dudley (DS). Shasta County: Redding, May, 1896, *M. S. Baker* (UC). Sonoma County: Altura, April, 1900, *A. Eastwood* (UC, US); Taylor Mountain, April, 1898, *M. S. Baker 631* (UC).

6. LUPINUS BICOLOR Lindl. Bot. Reg. **13**: *pl. 1109*. 1827.

This species was treated in the last paper of this series, (Bull. Torr. Club **50**: 373. 1923.).

7. LUPINUS MICRANTHUS Dougl. Lindl. Bot. Reg. **15**: *pl. 1251*. 1829. [Fig. 94.]

Lupinus polycarpus Greene, Pittonia **1**: 171. 1886.

Annual, rather stout and succulent or slender and dry, 10–40 cm. tall, simple or branched at the base, erect or the branches ascending, short-appressed or subappressed pubescent, and more or less villous, rarely densely villous with hairs 2 mm.

long; leaves several to many, thick and fleshy or rather thin, appressed pubescent below, glabrous or sparsely hairy above; petioles 5–8 cm. long; stipules subulate, often purplish-brown; leaflets five to seven, linear-oblanceolate to oblanceolate, 15–40 mm. long, by 2–6 mm. wide; peduncles 3–6 cm. long; racemes 1–8 cm. long, verticils two to seven, but usually three to five; flowers few to many, 5–8 mm. long; bracts subulate, purplish-brown, early deciduous; pedicels stout, 1–2 mm. long; calyx relatively large, minutely bracteolate, upper lip bifid, about 3 mm. long, lower lip broad, minutely three-toothed, 3–4 mm. long, three-nerved; petals blue and white, banner 6–8 mm. long, cuneate-obovate to spatulate, the purple-dotted white center often turning violet, the sides only slightly reflexed, wings 5–6 mm. long by about 3 mm. broad, keel short and broad, nearly straight along the upper edges, ciliate above the middle,

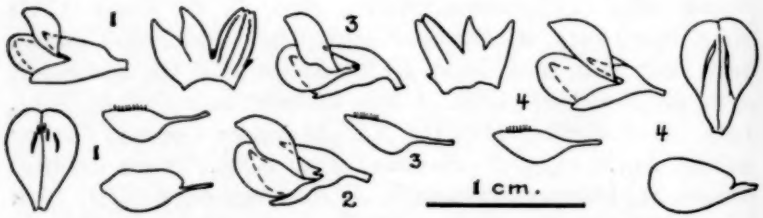

Fig. 94. LUPINUS MICRANTHUS Dougl. 1. *A. A. Heller 10,100*, Oregon, (CPS). 2. *C. P. Smith 3262*, Santa Cruz County (CPS). 3. *B. Dold 101*, San Francisco (CPS). 4. *J. W. Congdon*, Toulumne County (US 466,502).

the blunt acumen not well defined: pods 25–30 mm. long by 5–6 mm. broad, appressed-hairy, ovules six to seven; seeds oblong, rather thick, about 3 × 2 mm., gray or brown, usually much mottled and often with marginal or lateral lines.

Since the original description of *L. micranthus* has been so recently republished by Heller (Muhlenbergia **7**: 2. 1911), I will not reproduce it here. Neither the original description nor plate leaves any doubt in my mind as to the species to which this name must be applied. Just one descriptive phrase given by Lindley, namely: "keel falcate, acute," has made me hesitate at times; but the lower edge of the keel is much curved, as seen in many undissected flowers, while dissection shows the upper edge to be nearly straight. I have examined over one hundred collections of the species and hundreds of plants in the field, and fail to find first-class excuse for retaining *L. polycarpus* even as a variety. It is certainly a mere ecologic form of more

moist soils, showing only vegetative characters uncertain and non-dependable. Greene surely had an odd hallucination when he saw his *L. polycarpus* as "more related to the coarse, fleshy, large-flowered *L. affinis*" [*L. succulentus*] than to "the very different *L. micranthus*." Though quite variable in its vegetative parts, the flowers are remarkably constant in type, so that varietal classification must be based upon leaflets and pubescence, characters found by me to be largely unsatisfactory for such purposes, though at times offering real temptation.

Quite a few specimens examined are not cited below, especially some from Santa Clara County.

BRITISH COLUMBIA. Vancouver Island: Victoria, May, 1901, *A. J. Pineo* (BP, UC); same, May, 1908, *J. Macoun 78,884*, *-5*, *-6*, and *-7* (UCX).

WASHINGTON. King County: Seattle, June, 1891, *C. V. Piper 255* (UC). Klickitat County: Bingen, April & June, 1911, *W. N. Suksdorf 7203* (B, UC, CPS); same, June, 1911, *Suksdorf 7240* (B, UC, CPS); same, May, 1914, *Suksdorf 7743* (CPS).

OREGON. Douglas County: Winchester, May, 1922, *M. W. Gorman 5624* (CPS). Hood River County: Hood River, June, 1896, *L. F. Henderson* (DS); same, May, 1910, *A. A. Heller 10,100* (B, DS, CPS). Josephine County: Grants Pass, May, 1910, *A. A. Heller 10,024* (CPS); same, May, 1912, *H. S. Prescott* (CPS). Lane County: Eugene, April, 1920, *R. V. Bradshaw 1405* (CPS); same, May, 1922, *F. L. Wynd 971* (CPS); same, July, 1922, *C. P. Smith 3561* (CPS). Marion County: Champoeg, May, 1919, *M. W. Gorman* (DS); Chemawa, April, 1915, *J. C. Nelson 71* (DS); Gervais, May, 1922, *M. W. Gorman 5725* (CPS); Salem, April, 1921, *J. C. Nelson 3468* and *3529* (CPS); same, July, 1922, *C. P. Smith 3579* (CPS). Umatilla County: Pendleton, May, 1896, *T. Howell* (DS).

CALIFORNIA. Alameda County: Berkeley, May, 1893, *E. L. Greene* (UC); same, May, 1891, and May, 1893, *Michener & Bioletti* (UC); Oakland, April, 1921, *C. P. Smith 3338* (CPS). Butte County: Chico, April, 1903, *E. B. Copeland*, Baker's distribution 3043 (BP); Oroville, 8 miles N., March, 1914, *A. A. Heller 11,198* (CA, DS, UC, UCX). Calaveras County: Mokelumne Hill, *F. E. Blaisdell* (CA, CPS). Colusa County: Williams, April, 1917, *R. S. Ferris 545* (DS). Contra Costa County: Antioch, April, 1922, *C. P. Smith 3485* and *3486* (CPS); Byron

Springs, May, 1914, *A. Eastwood 3825* (CA); Moraga Valley, April, 1888, *V. K. Chesnut* (UC); Walnut Creek, *K. Brandegee* (UC). Eldorado County: Pilot Hill, April, 1915, *K. Brandegee* (UC). Glenn County: Willows, April, 1921, *A. Eastwood 10,220* (CPS). Humboldt County: Alton, May, 1912, *J. P. Tracy & E. B. Babcock* (UC); Bucksport, June, 1911, *J. P. Tracy 3251* (UC); Grizzly Creek, Van Duzan River, July, 1916, *L. R. Abrams 6035* (DS); Scotia, May, 1901, *H. P. Chandler 1094* (UC). Kern County: Tehachapi, *K. Brandegee* (UC). Marin County: Olema, May, 1913, *H. A. Walker 2971a* (UC); Point Reyes, May, 1906, *A. Eastwood* (CA); Sausalito to Larkspur, April, 1918, *L. R. Abrams 6883* (DS). Mendocino County: Ukiah Valley, Russian River, April, 1918, *L. R. Abrams 6978* (DS). Modoc County: no locality, Aug., 1893, *M. S. Baker* (BP, UC). Monterey County: Santa Lucia Mountains, May, 1920, *R. S. Ferris 1854* (CPS). Napa County: Calistoga, April, 1903, *C. F. Baker 1982* (B); same, *C. F. Baker 1988* (CA, UC); Napa City, 1893, *W. L. Jepson* (UC). Plumas County: Crescent Mills, July, 1921, *C. P. Smith 3419* (CPS); Greenville, June, 1920, *Mary S. Clemens* (CA); same, July, 1921, *C. P. Smith 3410* (CPS). San Bernardino County: Crafton, April, 1876, *J. G. Lemmon 122* (UC). San Diego County: Cuyamaca Lake, June, 1903, *L. R. Abrams 3840* (DS, US). San Francisco County: Twin Peaks, April, 1921, *Bertha Dold 101* (CPS). San Mateo County: Crystal Springs Lake, April, 1903, *C. F. Baker 1931* (BP, CA, UC); San Bruno hills, Bay Shore road, April, 1918, *L. R. Abrams 7054* (DS); San Mateo, April, 1921, *C. P. Smith 3297* and *3298* (CPS); Stanford Park, March, 1921, *C. P. Smith 3228* (CPS). Santa Clara County: Betabel, April, 1921, *C. P. Smith 3265* (CPS); Halls Valley, May, 1907, *C. P. Smith 1297* (CPS); Los Gatos, April, 1904, *A. A. Heller 7294* (B, DS, UC, UCX), same, April, 1911, *A. A. Heller 10,246* (B, BP, DS, UCX, CPS); Monto Bello Ridge, April, 1921, *C. P. Smith 3332* (CPS); Morgan Hill, April, 1921, *C. P. Smith 3253* (CPS); Sargent, April, 1921, *C. P. Smith 3272* (CPS); Stanford University, April, 1895, *W. R. Dudley* (DS); Wright, April, 1921, *C. P. Smith 3309* and *3310* (CPS). Santa Cruz County: Chittenden, April, 1921, *C. P. Smith 3261* and *3262* (CPS); Scott Creek, May, 1920, *R. S. Ferris 2012* (DS, CPS). Sonoma County: Bodega, May, 1900, *H. P. Chandler 671* (UC); Healdsburg, April, 1918,

L. R. Abrams 6915 (DS); Petaluma, April, 1908, *C. P. Smith 1379* and *1385* (DS, CPS); Santa Rosa, Sept., 1898, *M. S. Baker 707* (UC); same, April, 1902, *Heller & Brown 5226* (B, DS); same, April, 1918, *L. R. Abrams 6899* (DS). Sutter County: Marysville, March, 1905, *A. A. Heller 7560* (B, DS, UC, CPS). Tehama County: Corning, April, 1901, *H. C. Stiles* (UC). Yolo County: Davis, April, 1915, *P. B. Kennedy 27, 28,* and *33* (UCX).

Usually abundant where found, especially in the Bay Region. As recorded by both Dr. Greene (Pittonia **1**: 171. 1886) and myself (Muhlenbergia **6**: 141. 1911), this species is the least conspicuous of all when in flower; yet in fruit it is more conspicuous than *L. bicolor*.

Just one variety do I care to characterize here.

7b. **Lupinus micranthus Congdoni,** var. nov.

Erectus 5–8 cm. altus, caulibus gracilibus pubescentibus pilis brevis ascendentibus; foliis paucibus, petiolis 1–3 cm. longis, foliolis sex ad octo spathulatis 4–6 mm. longis 1–1.5 mm. latis utrimque pubescentibus; racemis 1–2 cm. longis, floribus paucibus alternis 6–7 mm. longis, pedicellis circa 1 mm. longis, petalis iis plantae typicae persimilibus; legumina seminaque non vidi.

Erect, 5–8 cm. tall, the slender stems pubescent with short ascending hairs; leaves few, the petioles 1–3 cm. long, the leaflets 4–6 mm. long by 1–1.5 mm. wide, six to eight, spatulate, pubescent on both sides; raceme 1–2 cm. long, flowers 6–7 mm. long, few and scattered, pedicels about 1 mm. long, petals not different from those of the typical plant.

CALIFORNIA. Tuolumne County: Big Oak Flat, Smith Ranch, Yosemite road, April, 1902, *J. W. Congdon* (TYPE, G; type-duplicates US 466,501 and 466,502).

Labelled, "*L. gracilis* Agardh," and annotated, "n. sp." I at first freely accepted it as a new species; but after making dissections and drawings of the floral parts, came to the decision followed here. It is certainly an odd extreme, evidently representing the result of a keen struggle for existence. My drawings are included in Fig. 94.

The abbreviations used herein, in citing specimens, are explained in the list below.

B, Brooklyn Botanic Garden;

BP, C. F. Baker Herbarium, Pomona College, Claremont, Calif.;

CA, California Academy of Science, San Francisco;
CPS, herbarium of the writer;
DS, Dudley Herbarium, Stanford University;
G, Gray Herbarium, Harvard University;
NY, New York Botanical Garden;
UC, Department of Botany, University of California;
UCX, Division of Agronomy, University of California Experiment Station;
US, United States National Herbarium.

* * * * * *

This paper completes my review of the annual and biennial lupines of North America, exclusive of Southern Mexico and southward. The next paper, therefore, will probably be concerned with some one of the several perennial groups that have already received considerable of my attention. It seems appropriate, then, to append here notes concerning certain forms, as follows:

Lupinus microcarpus scopulorum, comb. nov.

Lupinus densiflorus scopulorum C. P. Smith, Bull. Torr. Club **45**: 201. 1918,—as to Vancouver Island plants.

When this variety was published I made certain reservations, expressed in the following words:

While this form and var. *austrocollinum* may not be properly included in *L. densiflorus*, they certainly are less closely related to typical *L. microcarpus*.

In July, 1922, I had the pleasure of visiting Victoria, Vancouver Island, and studying this plant in its natural home and type locality. It was abundant, in full bloom, fruit, and seed, and I followed it along the seacoast cliffs, throughout the area occupied, looking for variations. Much to my surprise, I found the flowers to be constantly and conspicuously suberect or ascending in both the axial racemes and in all those of the branches. The petals are decidedly yellow in the fresh flowers, the fruits typical of the group, ovate, 10–12 mm. long, secund, the seeds dull, dark brown, unmarked, 5 × 4 mm. The plants are widely branched at the base, often also above.

Thus I was able to settle, in my own mind, all doubts as to the proper classification of the Victoria elements of my original treatment, the phrase, "floribus ad anthesin et postea panden-

tibus," applying to the Whidby Island and Fossil Island* elements only, and not to the Vancouver Island plants which I supposed were merely in bud. The form of the Puget Sound islands will be studied in the field, as soon as possible, and then disposition made of it according to my findings.

LUPINUS HAVARDII Wats., Proc. Am. Acad. 17: 369. 1882.

The idea of a perennial lupine of the *Sericei* along the upper Rio Grande in Texas has frequently started some mental speculations, and often have I entertained the desire to visit that region and investigate the matter. The specimens in the *L. Havardii* cover at the National Herbarium offered no help to a conclusion and I did not think to investigate the case when looking up the annuals at the Gray Herbarium. Recently access has been had to scraps of this, filed at the University of California, labelled as coming from the type at Harvard, and annotated, "*L. Havardii—leonensis* ?, annual." The questioned identification thus indicated is fully justified by the material concerned, a leaf, a flower, and dissected floral parts. Thus *L. subcarnosus* Hook. seems to claim a fifth synonym.† *L. bimaculatus* Hook. was described as a perennial, as well as *L. Havardii;* but why Watson should compare the latter with *L. sericeus* and *L. Sitgreavesii* I am not prepared to explain at this time. I see nothing in Watson's description to oppose the conclusion that *L. Havardii* is the same as *L. texensis* and *L. leonensis*, which are phases of *L. subcarnosus*, having narrower petals and leaflets.

LUPINUS UNCIALIS Wats., Bot. King's Rep. 54. 1871.

It would doubtless seem odd if I closed a series of papers upon the annual lupines of North America without referring to this species, the sole representative of Watson's subgenus *Lupinellus*. Watson's illustrations (Plate VII) are excellent and his description good enough; and I have examined the type specimens at the Gray Herbarium.

The character of "flowers axillary, solitary" is, indeed, a remarkable variation for the genus *Lupinus;* but I have already reported that in *L. concinnus* the very common axillary branches

* WASHINGTON.—San Juan County: Fossil Island, June 25 and Aug. 1, 1917, S. M. & E. B. Zeller 1229 (B).

† See Bull. Torr. Club 48: 230. 1921.

are sometimes reduced to mere racemes, as noted by Watson, himself, in his *L. Orcuttii*, and often also to one or two flowers only (Bull. Torr. Club **48: 222**. 1921). I therefore now confess, that, to me at least, *L. uncialis* is nothing more or less than an extreme reduction of *L. brevicaulis* Wats., described by him at the same time and illustrated in the same plate. His figures do not disprove this conclusion, and same should be compared with my figure 46, showing variations in *L. brevicaulis* (Bull. Torr. Club **46:** 397. 1919).

SAN JOSE, CALIFORNIA.

Expression of the sexual state in Sagittaria latifolia*

JOHN H. SCHAFFNER

In 1921, the writer† published a paper on the nature of sexual expression in those plants which have a definite reversal of sex in the inflorescence, one part of the axis bearing staminate and the other carpellate flowers. *Sagittaria latifolia* Willd. was mentioned as being a plant of this type with carpellate flowers below and staminate flowers above.

During the past summer the opportunity was presented for an extensive study of this plant in the field, observations being made in Ohio, Missouri, Kansas, and Colorado. As will be seen from the facts presented below the development of flowers in *Sagittaria* agrees completely with the idea that sex is dependent on a functional state of the protoplasm and that when there is alternative sexual expression or sex reversal in the inflorescence axis there must be a neutral zone of tissue, of greater or less extent, between the two parts.

The inflorescence of *Sagittaria* is commonly a scapose, simple raceme with the flowers in whorls of threes. Quite frequently one or more members of the lowest whorl are developed as branches giving rise to a paniculate inflorescence, which probably represents a more primitive evolutionary stage. In the manuals, *Sagittaria latifolia* is described as normally monecious or occasionally diecious. Buchenau in "Das Pflanzenreich" also describes it as "Monoeca, rarius dioeca." Probably this statement means only that entire inflorescences are known to be purely staminate or purely carpellate. Since the plant is perennial, stoloniferous and tuberiferous it would be difficult to determine whether entire individuals were staminate or carpellate unless the plants were subjected to experimental control. The stamen vestiges of the carpellate flowers are usually small and few in the lower flowers, while near the top of the carpellate inflorescence they are more numerous and more perfectly developed. Usually

* Papers from the Department of Botany. The Ohio State University. No. 145.

† SCHAFFNER, JOHN H. Reversal of the sexual state in certain types of monecious inflorescences. Ohio Jour. Sci. **21**: 185–200. 1921.

also the carpel vestiges are more perfectly developed in the lowest staminate flowers. Commonly the transition is abrupt from carpellate whorl to staminate whorl.

Since, as intimated above, in passing from the female to the male state the inflorescence bud must pass through a neutral condition, it becomes evident that this may occasionally take place in a node rather than in the internodal tissue. It is then possible for one side of the axis to pass into the one sexual condition and the other side into the opposite sexual condition. Such cases were found to be quite common, the transition whorl containing one carpellate flower and two staminate flowers or two staminate and one carpellate. It is also evident that a flower incept may be exactly on the neutral tissue and then continue for a while in the neutral state, in which case the original, bisporangiate flower, from which type *Sagittaria* evolved, should again be produced. A search for this condition showed the reasoning to be correct: such bisporangiate flowers of all degrees of staminateness and carpellateness being not at all difficult to find. In fact they are quite frequently developed. One flower was found with a nearly equal number of good stamens and normal carpels. But usually there are only a few normal carpels at the tip of the flower, which soon become green, or a few normal stamens at the base together with the vestiges. There are also flowers which have nearly perfect carpels but which are plainly staminate in general nature and some which are plainly carpellate but with a few imperfect stamens. From these conditions one can find all gradations to the ordinary type of staminate and carpellate flowers with the usual types of vestiges for each.

When the basal whorl develops one or more branches, they often change immediately, or after the production of one or two carpellate flowers, to the staminate condition while the main axis may continue to be carpellate for some distance up. Bisporangiate flowers are apt to be produced in the lower part of such branches; for there is apparently a slight disturbance of the normal progression of functional states as the branch develops. One such branch was found which had its terminal bud slightly injured through some unknown cause and which showed a complete reversal of the normal sexual development. The lowest whorl of this branch was staminate and the next node

ended the growth with a single large carpellate flower. There was in this case, therefore, a complete reversal of sex, as stated, in the opposite direction from what usually takes place, a change from the male to the female condition in the progressive development of the inflorescence axis. Apparently it required but a slight change in the physiological activity to throw the branch from the female state to the male state and then back to the female state again. The other two basal branches of this compound inflorescence were carpellate below and staminate above in normal order. This case brings out an important point and shows that with a proper knowledge of the functional states of the protoplast, it should be possible to bring out reversals of sex of an opposite nature from that which the heredity of the plant allows under the normal environment of the species.

The reversal of the sexual state from female to male typically takes place at or near the middle of the inflorescence axis. It may take place at any point, however, through all gradations from inflorescences with an equal number of carpellate and staminate flowers to those in which there is a single carpellate flower at the base or a single staminate flower at the tip. The next step results in monosporangiate inflorescences. If the male condition is determined before the development of the first flower incept the entire inflorescence is staminate, there being no reversal to the female state under normal conditions. If the female condition is determined at the beginning as is normally the case and this state is continued to the end, the entire inflorescence must, of course, be carpellate. Since in the field the patches of plants are usually crowded with interlacing rhizomes, it was not possible to determine whether any individual was completely staminate or carpellate. Theoretically such a condition must occasionally be produced in any given season.

The following data which are taken from a single gathering of inflorescences in a patch of *Sagittaria*, growing in a ditch along the roadside east of Manhattan, Kansas, will show what one can frequently find in the field. The list does not show the proportion of monosporangiate inflorescences to bisporangiate inflorescences, since they were gathered especially with reference to their apparently extreme staminateness or carpellateness and the ordinary monecious ones were passed by.

1. A compound inflorescence with two basal branches, with a large number of staminate flowers having the usual vestigial carpels. In the basal whorl with the two branches there was a carpellate flower or rather a bisporangiate flower with a large number of normal carpels, with three pollen-bearing stamens and a considerable number of large stamen vestiges. The head of carpels was of normal size. In the second node of the main axis there was one staminate flower together with one staminate intermediate flower with a few perfect carpels, and a carpellate intermediate flower with twenty pollen-bearing stamens, a number of stamen vestiges, and a large number of normal carpels. The rest of the inflorescence was staminate.

2. A simple inflorescence with all the flowers carpellate.

3. A compound inflorescence with all the flowers staminate.

4. A compound inflorescence, the first whorl with one staminate branch, one staminate flower, and one carpellate flower with normal stamen vestiges. The rest of the inflorescence was staminate.

5. A simple inflorescence completely staminate.

6. A compound monecious inflorescence, the lower half carpellate, the upper half staminate.

7. A compound inflorescence with one branch in the lowest node. The first whorl of the main axis contained one normal carpellate flower; the rest of the inflorescence was staminate.

8. A compound staminate inflorescence with three basal branches.

9. A completely carpellate, compound inflorescence but the upper flowers with unusually large staminodes, none, however, bearing pollen.

10. A completely carpellate, simple inflorescence with all the flowers typical.

11. A completely carpellate, compound inflorescence.

12. A compound inflorescence with two carpellate flowers in the lowest whorl together with a staminate branch; the rest of the main axis was staminate.

13. A simple, completely staminate inflorescence.

14. A compound, completely staminate inflorescence.

15. A normal monecious inflorescence.

16. A completely staminate, compound inflorescence.

17. A completely staminate, compound inflorescence.

18. A compound inflorescence: the first node with one staminate branch, one carpellate flower with large stamen vestiges, and one partly carpellate flower. This flower had a large number of normal, green carpels, six pollen-bearing stamens, and a number of stamen vestiges. The remaining part of the inflorescence was staminate.

DISCUSSION AND CONCLUSIONS

It is evident that the different expressions or types of inflorescences do not depend on differences of hereditary constitution. The genotype is the same, and the diversity of sexual expressions between different inflorescences and different branches or flowers of the same inflorescence represent alternative functional activity. Recently Stout* has come to similar conclusions in his paper on alternation of sexes in Cleome. He says that—"The theory of sex chromosomes decidedly fails in general application to plants, and even in animals, where its application seems most marked, sex is often intergrading and reversible, showing that there is alternative expression rather than alternative inheritance."

One of the most unwarranted developments of recent genetic analysis is the setting up of an inadequate or rather improper symbolism to designate monecious and hermaphroditic states. One might, with nearly as much reason, use a genetic symbol for ontogenetic fluctuations, as to have a simple symbol H for the heredities that lead to the many different types of normal and abnormal monecious conditions. There is a large number of types of moneciousness, and so far as sexual condition is concerned a plant with bisporangiate flowers is not fundamentally different from the monecious types. Individuals of both types express both maleness and femaleness in their bodies. There are hereditary factors or groups of factors which are responsible for the different types of hermaphroditic and bisporangiate expressions developed under their normal environments, as well as for those which are unisexual or monosporangiate. The hereditary background is fundamental. But the expression of any type of sexual condition in the individual is not to be inter-

* STOUT, A. B. Alternation of sexes and intermittent production of fruit in the spider flower (Cleome spinosa). Am. Jour. Bot. **10**: 57–66. 1923.

preted as being due to the presence or absence of a specific sex chromosome gene or set of genes. The sexual expression changes with the proper change of environment as has been abundantly shown by the writer and others through direct experiment. Therefore sexuality as maleness or femaleness is not primarily a matter of heredity. There can be no doubt that apparently the functional activity which leads to maleness or femaleness under the given environment or at the proper stage in the ontogeny may depend on the properties of a single chromosome in some groups, and in others on a number of chromosomes. But even with such chromosomes present it would still be possible to change the sexual state, since the influence of such hereditary factors must be the same in bringing about a given sexual state of the cell, whether neutral, male, or female, as any other influence which affects the metabolic processes. As stated above, the writer has shown by observation and direct experiment in a considerable number of plants that the sexual expression of an individual or part of an individual as male, female, or hermaphrodite, of various type and degree, is not at all due to a compelling sex factorial arrangement in the organism and that the same individual may at one time be pure male, at another time pure female, and at another hermaphroditic. The given sexual character can only be understood and explained by the circumstances of its expression even though we believe that the expression of a given sexual condition must come through an ultimate hereditary constitution which permits or leads up to that condition under the given environment.

It is, therefore, entirely superficial and contrary to both observation and experimental evidence to treat sexual expressions and sexual characters as being dependent on three simple Mendelian factors and their combinations, namely, F, M, H, FM, FH, MH, or whatever such symbols are employed. The inadequacy of such a procedure becomes evident when one can cause all the characters, which are supposed to be due to such different factorial combinations, to be developed in a single individual.

If one takes a comprehensive view of the plant kingdom certain fundamental facts become prominent. Sexuality in the lowest organisms is purely physiological. In the higher plants the segregation of chromosomes has nothing to do with the

sexual expression, the sex of the gametophyte coming through the process unchanged. Unisexual forms are plainly related by intergradations to the more primitive hermaphrodites. Sex is from the lowest to the highest expressed in three simple states, female or positive, male or negative, and neutral, but with numerous gradations of intensity and fixity between either extreme and the neutral condition. Sex is definitely reversible, in many cases at least, through environmental influence. Mendelian phenomena and unit factors are concerned with minute morphological and physiological characters of multitudinous diversity, ranging from the unicellular forms to the higher plants and the higher animals. The phenomena of sexuality are entirely different. The evolution of primary sexual dimorphism is attained, being practically complete, before the multicellular condition is reached. Secondary sexual characters of the lower forms are in no way different from those of the higher. The only difference is that in the higher the cell has a larger number of factors which may become dimorphic or trimorphic. It is only in a few plants and in the higher animals that there is a seeming similarity to Mendelian segregations, because of the sex ratios obtaining and because of a certain type of association of specific chromosomes which it has become the vogue recently to call "sex chromosomes." Such allosomes with peculiar differential complements of factors, which are not to be regarded as of any different nature from other factors in other chromosomes, may and no doubt do in certain groups of organisms give the cell a functional activity that leads to a specific sexual state under the ordinary environment of the species and the ordinary hereditary complex. But the control is brought about in the same way as through any other environmental influences, like length of illumination period, external nutritive supply, etc., which are known to control or modify the sexual state in the individual. It is far better to call these special chromosomes "allosomes" in contradistinction to the "autosomes" as was done by Montgomery,* who proposed the terms, rather than "sex chromosomes." The matter will thus be considerably cleared for a rational and understandable discussion of the prob-

* MONTGOMERY, JR., THOS. H. The Terminology of aberrant chromosomes and their behavior in certain hemiptera. Science N. S. **23**: 36–38. 1906.

lems of sex. The term allosome implies no special hypothesis as to the nature of these bodies. From a general or fundamental point of view, every chromosome of a sexual organism is a "sex chromosome"; for apparently in gametes the primary sexual property of attraction is possessed to a high degree by the chromatin. The attractive property disappears or is neutralized when the two sex nuclei have united. Now at synapsis, in the reduction division, this primary attractive property develops again but the attraction is between the specific pairs of chromosomes in the diploid nucleus, whether the cell be an oöcyte or spermatocyte, a megasporocyte or microsporocyte, or a more primitive homosporous sporocyte, zygospore, or primitive oöspore. Attractive properties appear between the specific pairs of chromosomes and continue until the extreme folding or looping stage of synapsis when the two members of the diploid chromosome seem to be neutralized and are then soon separated by the reduction spindle. There is no need of assuming that this attractive property of the synaptic chromosomes is anything different from the sexual attraction shown at a previous stage between the entire male and female nuclei which are usually in the resting stage during fusion. The dimorphism of allosome pairs, together with their apparent differences in complements of hereditary factors, may have a decided influence over the attractive states which arise in them, both while they are in synapsis and while they form a part of the chromatin masses of conjugating male and female nuclei. And this specificity may lead to differential attraction between the gametes.

The evolution of sex from the primitive, physiological, isogamous condition has come about by the shifting of the origin of the male and female states into an earlier and earlier stage of the sexual cell ontogeny. In case of the primary or gamete sexual characters, the lowest type shows gametes with no apparent morphological difference. The sexual state evidently does not arise until the development of the gamete is complete. By a succession of forms in many independent lines the extreme dimorphism of egg and sperm is soon attained. This progression can be explained by assuming that the origin of the sexual state arises at an earlier and earlier stage of the ontogeny of the gamete as stated above. When it arises with

sufficient intensity at the very beginning of the development of the gametes, the greatest dimorphism results. The heterogametes of the higher organisms, whether plant or animal, are not different in general aspects from those near the base of the evolutionary series.

The evolution of the secondary sexual states and characters is along exactly similar lines. In the simple sexual plants and in gametophytes with an alternation of generations, there is a progression from the condition where dimorphism arises only at the end of the ontogeny in cells and tissues immediately contiguous to the gamete-producing cells, and the progression leads backward from this condition through sex determination at earlier and earlier stages of the ontogeny until the entire individual is involved, the determination of sex taking place, or being already determined, in the spore from which the gametophyte arises.

Finally, there is an exactly similar progression in the evolution of sexual states in the sporophyte. In the lowest heterosporous sporophytes the secondary sexual states arise side by side at the end of the ontogeny, namely, when the sporangia are produced, just as they do in the primitive hermaphrodites. Then the different types fall into an orderly progression of earlier and earlier sex determination; first the male and female states arising in the same sorus, second in separate sori of the same leaf, and third in entirely different sporophylls, giving rise to bisporangiate flowers. This condition remains in most groups even to the very highest. From the condition of bisporangiate flowers there are various types and degrees of moneciousness, with the sex determined at the base of or beyond the floral axis, up to the complete diecious condition. The determination of sex is again thrown back into earlier and earlier stages of the ontogeny until it coincides with the development of the female gamete or the time of its fertilization.

In view of these evident conditions and the nature of sexual expression in monecious plants together with the fact that the sex of diecious sporophytes can be reversed in both directions, the writer* in an earlier paper said that the characters of an

* SCHAFFNER, JOHN H. Progression of sexual evolution in the plant kingdom. Ohio Jour. Sci. **22**: 101–113. 1922.

organism appear to be conditioned on the interaction of four fundamental causes:

1. The presence of hereditary factors in the protoplast, apparently properties of the chromosomes. This is, of course, the fundamental influence or cause.

2. The influence of environment, both external and internal, giving rise to fluctuations, often resulting in very great morphological and physiological differences.

3. The progression of senility or rejuvenation which often has a decided effect on the hereditary expression.

4. The presence or absence of sexual states in the living substance through which primary and secondary sexual characters or dimorphisms are produced without a change in genotype.

In so far as the evidence goes, the observed conditions of the monecious state in *Sagittaria* are in entire agreement with these conclusions.

OHIO STATE UNIVERSITY.

INDEX TO AMERICAN BOTANICAL LITERATURE

1923

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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